A B S T R A C T

Degradation behavior of polymeric materials for solar thermal applications

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In close cooperation between the Polymer Competence Center Leoben (PCCL, Leoben, A) and the University of Oslo, Department of Physics (Oslo, N) a research program was established to investigate the aging behavior of polymeric materials for solar thermal absorbers. Various commodity and engineering plastics grades were selected and characterized as to their long long-term behavior under application relevant conditions.

This work focuses on the description of the degradation behavior of two grades (. a polyphenylene ether blend (PPE+PS, currently used in the all polymeric Solarnor collector) and polypropylene (PP)). The reference material and the aged specimens were characterized by mechanical methods (monotonic tensile test) and by analytical methods (Differential Scanning Calorimetry, DSC; size exclusion chromatography (SEC); infrared spectroscopy in attenuated total reflection mode (ATR)). In accordance with the experiences made with the Solarnor collector, 140 °C in air and 80 °C in water were considered as application relevant aging conditions. Maximum exposition times were 500 hours in hot air and 16000 hours in hot water.

The investigations revealed that ultimate mechanical properties and average molecular weight values were the most sensitive parameters to describe the degradation behavior. For the investigated PP grade no evidence for degradation could be found within the specified exposition time by DSC, SEC and ultimate strain values. However, by ATR degradation products such as hydroxyl and carbonyl groups were revealed at the surface of the PP specimens. Furthermore, diffusion of HALS additives was detected by an increase of the absorption peak at 1540 cm^{-1}.

The investigated PPE+PS grade exhibited a more significant degradation behavior within the specified exposition time. After exposition in hot air, a strong decrease in ultimate strain values was obtained for the PPE+PS grade. By SEC results a significant major decrease of the average molecular weight values was obtained for the PS component in the PPE+PS blend. For PPE a slight increase and thus cross-linking was found. As illustrated in Fig. 1, the exposition of PPE+PS specimens in hot air at 140 °C yielded an full embrittlement of the specimen (ultimate strain values below yield point) associated by an decrease of the average molecular weight of the PS component from initially 160.000 g/mol to values below 110.000 g/mol. Also after exposition in hot water, the ultimate strain values of the PPE+PS specimens decreased continuously with aging time.

Compared to the reductions in ultimate strain measured after exposition in hot air, a less significant embrittlement was obtained for the specimens exposed to hot water. By SEC a decrease of the average molecular weight of the PS component was found. No significant changes were detected for the PPE component. As shown in Fig. 2, for average molecular weight values above 130.000 g/mol of the PS component a ductile mechanical deformation behavior with ultimate strain values above yield point was obtained. The Oxidation temperature of the PPE+PS blend, determined from the DSC plots, did not change after both aging conditions, thus being no indicator for chemical degradation. By ATR r a loss of stabilizers, indicated by arising peaks at 1658 and 1694 cm^{-1}, and the evolution of hydroxyl and carbonyl degradation products was detected for the investigated PPE+PS grades.
Further details on the aging behavior compared with results found in literature will be described and discussed in the full poster.

Keywords: solar absorber, polymers, chemical aging, water, air

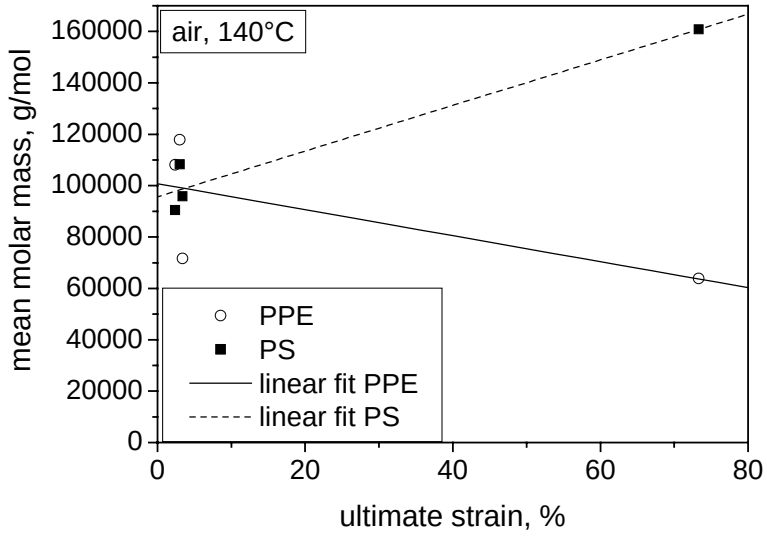

Fig. 1: Average molecular weight versus ultimate strain after aging in hot air at 140 °C for the investigated PPE+PS blend.

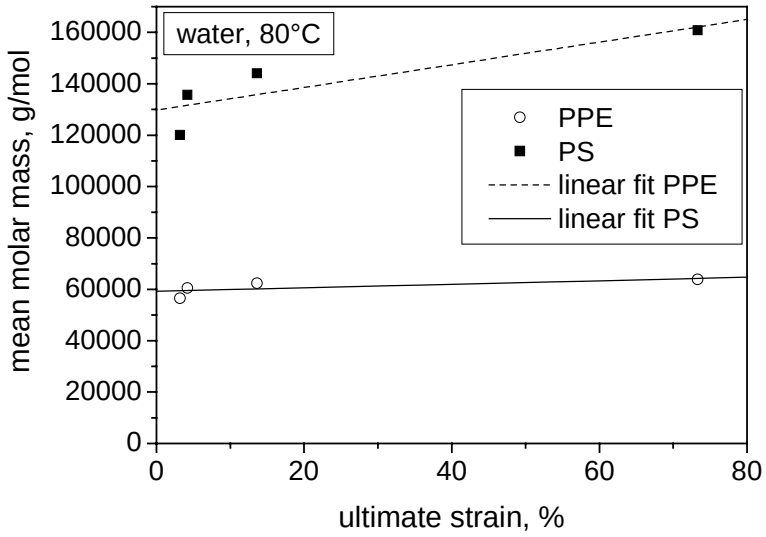

Fig. 2: Average molecuar weight versus ultimate strain after aging in hot water at 80 °C for the investigated PPE+PS blend.

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